Influence of potassium fertilization on yield components and resistance to leaf miner and aphid infestations of *Vicia faba* L.

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Abstract: The study aimed to investigate the effect of potassium (K_2O) application on some yield components of broad bean (*Vicia faba* L.) and infestation incidence with cowpea aphid (*Aphis craccivora* Koch) and bean leaf miner (*Liriomyza congesta* Becker). Field trails were conducted at the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt, during two successive seasons (2007/08 and 2008/09) on faba bean cultivar Giza 402. It is a sensitive cultivar to insect infestation. Faba bean yield components as well as the resistance to insect infestations were significantly influenced by potassium fertilization. Soil or foliar potassium applications significantly increased seed yield and its components, while decreased populations of *A. craccivora* and *L. congesta* in the tested Giza 402 plants. The soil-foliar combined application of K_2O was the most effective one. The yield components via days to 50% flowering, leaf chlorophyll content (SPAD value), number of pods/plant, and seed yield (g/plant) were increased gradually with increasing levels of potassium application. Also, the rate of resistance to *A. craccivora* and *L. congesta* infestations was increased with the increase of potassium levels in both seasons. The obtained results confirmed that the selection to the high level of resistance of insect infestations depends on content of the leaf chlorophyll, while there was no effect of the shedding rate on selection for resistance degree to insect injury. The regression relationship was found between the reduction of insect infestation and K_2O levels at different application regimes in all treatments. Also, liner equation of the coefficient of determination (R^2) confirmed that the breeding program for improving seed yield of faba bean (Giza 402) should include resistance to insect injury of *L. congesta* and *A. craccivora*.

Keywords: Faba bean, yield components, *Liriomyza congesta*, *Aphis craccivora*, infestations, potassium fertilization.

INTRODUCTION

Faba bean, *Vicia faba* L. is one of the most important legumes worldwide. It plays an important role in a human food in developing countries. It has been considered as an important source of proteins diet as a meat extender and as a skim milk substitute for both human and domestic animals diet in Egypt and many countries all over the world (Thalji, 2006). According to FAO, the world cultivated area in 2003 was approached 2.6 million hectares for dry seeds of faba bean, with a total production of about 4.1 million metric tons (FAOSTAT, 2004). Egypt is reported to be the third country in the major production areas, grew 0.14 Mha and its production was estimated to be 0.44 Mt in the same period (Torres *et al.*, 2006).

Faba bean is heavily attacked by serious pests, which consider a limiting factor for the production, reducing its quality and quantity. The major insect pests that destruct the green parts of bean in Egypt are the cowpea aphid, *Aphis craccivora* Koch (Homoptera: Aphidae), and the leaf miner, *Liriomyza congesta* Becker (Agromyzidae: Diptera) (El-Hosary *et al.*, 1998; Awaad *et al.*, 2005 and Ebadah *et al.*, 2006). Cultivar Giza 402 of *V. faba* is sensitive to attack by *A. craccivora* and *L. congesta*, (El-Hosary *et al.*, 1998 and Awaad *et al.*, 2005). *A. craccivora* causes direct damage to plant by piercing into phloem and feeding on soluble plant nutrients. This slows the rate of stem elongation, leaf production and decreases flower production, leading to wilt and collapse of the plant. Aphids also, caused indirect damage through transmission of plant viruses and stimulating formations of honeydew. Aphids have a very high multiplication rate due to its parthenogenesis and viviparity (Weigand and Bishara, 1991). *L. congesta* is the most widely distributed on faba bean fields in Egypt (Ebadah *et al.*, 2006). The larvae of *L. congesta* attack mainly the primary and secondary leaves of broad bean, where they feed on the leaf parenchyma, producing a characteristic form of mines. The high densities of leaf miners may severely reduce crop value or yield or kill the plants (Spencer, 1990).

Recently, there is an urgent need to improve *V. faba* yield, since this crop is fiercely attacked by numerous insects, leading to steady reduction in the crop. Several programs of pest control have been developed to enhance resistant varieties and their production. Increasing yield of faba bean could be achieved by using the high yielding cultivars, improving agricultural practices such as using fertilizers, which is one of the important limiting factors for crop production.

Potassium (K^+) is one of the essential elements for all living organisms. In plants, it is an important cation, comprising almost 6% of a plant's dry weight and involved in different physiological pathways (Duke and Collins, 1985). Potassium is the main osmotic solute in plants (Mengel and Arneke, 1982). Its accumulation in the cell favours water uptake, thus generating the cell turgor pressure required for growth (Mengel and Arneke, 1982) and stomatal opening (Fischer and Hsiao, 1968). Moreover, it is involved in activating a wide range of enzyme systems, which regulate photosynthesis, water use efficiency and movement, nitrogen uptake and protein building (Nguyen *et al.*, 2002). Also, potassium application can improve the water content in the broad bean leaves, which leads to more tolerance of plants to drought stress (Thalooth *et al.*, 1990). Potassium (K_2O) is the main form of potassium fertilizer used for crops allover the world (Barber *et al.*, 1985).

Although the interactions between plant nutrient levels and stress repair mechanisms have great attention, foliar applied nutrient is of limited use for enhancement stress resistance mechanisms in field crops. Thus, efficient cell development, growth of plant tissues, translocation, assimilation and other internal functions require adequate K^+ in the cell sap (Lindhauer, 1989).

Therefore, the present work was conducted to evaluate the effects of potassium fertilizer at different levels and application regimes on the growth and seed yield and its components of faba bean. Also, its effect on rate of infestation with *Liriomyza congesta* and *Aphis craccivora* was studied under field conditions. Moreover, the relationship between the reduction percentage of insect infestations and K_2O levels at different application regimes was estimated. Likewise, the relationship between seed yield and each studied traits were also confirmed herein.

MATERIALS AND METHODS

Experiment site and soil characters:

Two field experiments were conducted under three potassium fertilization regimes; soil application (PSA); foliar application (PFA) and soil-foliar application (PSFA). These experiments was carried out at the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt during two successive growing seasons of faba bean, 2007/08 and 2008/09. The soil texture of experimental site was sandy soil (94.5% sand, 2.5% silt and 3.0% clay) with pH of 7.8. The potassium content in the soil experiment was varied from 0.5–1.5% in root zone, with available part of 0.2%. The rate of potassium available was 11.65 and 11.90 mg/L during the two seasons of 2007/08 and 2008/09, respectively.

Seeds resource:

Seeds of *V. faba* cultivar Giza 402 were obtained from Food Legumes Research Department, Agriculture Research Center, Giza, Egypt. This cultivar is recognized as susceptible cultivar to infestation with the leaf miner, *L. congesta* and cowpea aphid, *A. craccivora* (El-Hosary *et al.*, 1998 and Awaad *et al.*, 2005).

Treatments:

In both growing seasons, no insecticide was used. The treatments included three application regimes of potassium sulfate (K_2O): soil, foliar and soil-foliar application. Each regime applied at three levels of K_2O, in addition to untreated control as follows (Table 1).

The amount of fertilizer in each treatment was divided into four equal parts and supplied to faba bean plants four times; 20, 40, 60 and 80 days post sowing.

Experiment design:

Split-plot design was used in this experiment. The treatments were replicated three times. Each plot was 4.0 m long and 1.8 m in width, four-rows in each plot. Spacing between rows = 45 cm, and spacing between plants in the same row =20 cm. Control treatments were also conducted with no potassium application in similar field plots. All agronomic practices were regularly carried out through different growing stages of faba bean plants in both seasons when required.

Estimation of infestation rate of *L. congesta* and *A. craccivora*:

Plants were examined weekly for the presence of *L. congesta* or *A. craccivora*. One hundred leaflets were randomly collected from each plot separately at the lower, middle and upper parts of the plants at 7 days intervals during bud formation till harvest. The collected leaflets were put in a polyethylene bags and transferred to the laboratory where they were examined under binocular microscope. Number of mines and larvae of leaf miner *L. congesta*, as well as the number of adults and nymphs of cowpea aphid *A. craccivora* were recorded. The first date of inspection was done after one month of plantation date.

The reduction percentage of insect infestations was calculated for the combined of both seasons 2007/08 and 2008/09, in addition to the relations between reduction of insect infestations and K_2O levels at application regimes were analyzed by linear regressions coefficient (R^2).

Measurement of studied characters:

Chlorophyll content:

The leaf chlorophyll content was evaluated during flowering stage using chlorophyll meter which estimate value of SPAD [SPAD 502, Soil-Plant Analysis Development (SPAD value) section, Minolta Camera Co. Osaka, Japan] according to Castelli *et al.* (1996).

Shedding percentage:

The total shedding percentage in the plant stem was recorded as follow:

$$\text{Total shedding percentage} = \frac{\text{No. of flowers - No. of mature pods}}{\text{No. of flowers}} \times 100$$

Other yield characters:

The other characters represented in days of 50% flowering, numbers of branches/plant, number of pods/plant, and seed yield (g/plant) were recorded.

Table (1): Potassium application treatments and its levels used in this study.

Levels	Treatments		
	Potassium Soil Appl. (PSA)	Potassium Foliar Appl. (PFA)	Potassium Soil - Foliar Appl. (PSFA)
Control	0	0	0
Level I	24 Kg K_2O/Fad.*	0.48 Kg K_2O/Fad.	24 + 0.48 Kg K_2O/Fad.
Level II	48 Kg K_2O/Fad.	0.96 Kg K_2O/Fad.	48 + 0.96 Kg K_2O/Fad.
Level III	72 Kg K_2O/Fad.	1.44 Kg K_2O/Fad.	72 + 1.44 Kg K_2O/Fad.

*Fad. = Faddan (4200 m^2)

Genetic parameters:

The relations between seed yield and other yield components were analyzed by linear regressions coefficient (R^2). Phenotypic correlation coefficient (rph) for all studied characters was also considered in this study.

Statistical analysis:

Data were statistically analyzed using CoStat V. 6.311 (CoHort software, Berkeley, CA94701). Application regime treatments (A), potassium levels (L) and their interaction (L*A) for all tested yield components including the averages of insect injury were compared using least significant different, LSD at 0.05 (Steel and Torrie, 1980). Probability levels lower than 0.05 were held to be significant.

RESULTS

Effect of K_2O on seed yield and its components:

Data presented in Fig. 1 shown the effect of different fertilization regimes of potassium sulfate at different levels on some yield components of faba bean cultivar Giza 402, during the 2007/08 and 2008/09 growing seasons. These data revealed that, there are significant differences ($P \leq 0.05$) between the three fertilization regimes in all tested yield compounds of faba bean Giza 402; days to 50% flowering, leaf chlorophyll content (SPAD value), shedding rate (%), number of pods/plant, and seed yield (g/plant) in both seasons, except number of branches/plant, which showed non-significant difference in the first season (Fig. 1).

Data indicated that the soil-foliar application of potassium fertilizer was the best treatment in both seasons compared to the foliar or soil application alone for seed yield and its components. The increasing levels of potassium sulfate in different fertilization regimes caused significant increase yield and its components of faba bean in both seasons, except for the percent of shedding rate, which decreased significantly with the increase of potassium levels (Fig. 1).

Significant differences were observed in the interaction among the different levels of potassium and the application regimes in both growing seasons (2007/08 and 2008/09). The data in Fig. (1) revealed that the application of the third level of potassium fertilizer (72+1.44 Kg K_2O/Fad.) in the case of soil-foliar regime was the most effective. This was followed by the third level of foliar application (1.44 Kg K_2O/Fad.) and the second level of soil application (48 Kg K_2O/Fad.) in all tested parameters, except that of the shedding rate.

Effect of K_2O on plant resistance to insect infestations:

Effect of K_2O on insect population density:

Data presented in Fig. 2 shown the effect of different fertilization regimes of potassium sulfate at different levels on the population density of *L. congesta* and *A. craccivora* for faba bean cultivar Giza 402, during the 2007/08 and 2008/09 growing seasons. Data indicated that the population of *L. congesta* and *A. craccivora* at the tested application regimes and different levels of potassium fertilizer exhibit density to the less abundant compared to control. For *L. congesta,* there was significant decrease ($P \leq 0.05$) in the mean number of mines and larvae during the first and second growing seasons of 2007/08 and 2008/09 (Fig. 2).

Data in Fig. (2) indicated that the mean number of *L. congesta* mines as well as the density of larvae decreased with the increase of potassium levels supplying in all types of K_2O application. The lowest incidence of *L. congesta* was recorded in the plots applied PSFA at third level of 72+1.44 Kg K_2O/Fad being 135 and 123 mines/100 leaflets; 87 and 76 larvae/100 leaflets in the growing seasons of 2007/08 and 2008/09, respectively.

Pertaining to *A. craccivora,* data were in the same trend as those of *L. congesta.* Data presented in Fig. (2) revealed that the lowest incidence of *A. craccivora* (nymphs and adults) was observed in the plots applied PSFA at third level 72+1.44 Kg K_2O/Fad at 123.67 and 78.00 individuals/100 leaflets in 2007/08 and 2008/09, respectively.

Significant differences were also observed in the interaction between the different application regimes of potassium and their levels in plant resistance to *L. congesta* and *A. craccivora* infestation in both growing seasons (Fig. 2).

b. Interaction between K_2O and reduction of insect infestation:

The relationships between the reduction percentage of insect infestation and three levels of potassium fertilization at different application regimes for the combined of both growing seasons of faba bean, 2007/08 and 2008/09 were computed as a coefficient of determination based on the simple linear regression (Fig. 3 and Table 2). Data presented in Fig. 3 indicated that the potassium fertilization at different application regimes showed comparable influence on the reduction of infestation rate for *L. congesta* and *A. craccivora.* Results further proved that the coefficient of determination (R^2) for *A. craccivora* in the infestation reduction was very high at values of 0.999, 0.997 and 0.956 in PSA, PFA and PSFA, respectively. The R^2 of *L. congesta* infestation reduction was estimated for mines as 0.951, 0.972 and 889; 0.956, 0.865 and 0.890 for *L. congesta* larvae in PSA, PFA and PSFA, respectively.

The effect of potassium levels at different application regimes on the reduction of insect infestation in *V. faba* plants was described by linear regression equations models (Table 2). The equations showed that the reduction of insect infestation will increase by the increase of potassium level (x) in all application regimes. The equations indicated a difference in the rate of infestation reduction for different species, as all slopes were significantly different from each to other. The slopes of linear regression equations caused upward trend in all treatments (Fig 3).

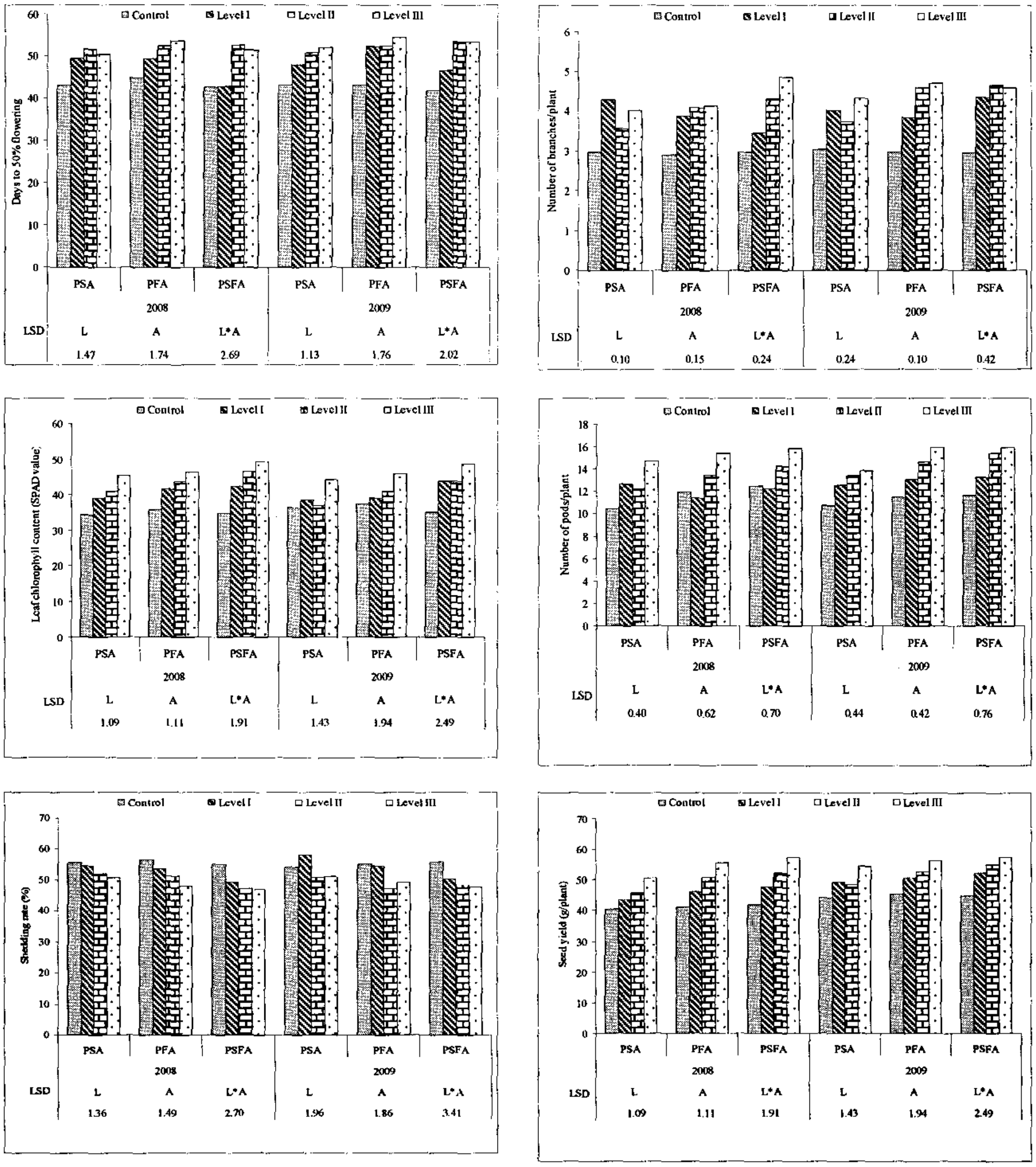

Fig. (1): Effect of Potassium sulphat fertilizer regimes and their levels on days to 50% flowering, number of branches/plant, number of pods/plant, leaf chlorophyll content, shedding rate (%) and seed yield (g./plant) in faba bean (Giza 402) during growing seasons of 2007/08 and 2008/09.

L= Levels A= Type (regime) of Application L*A = Interaction between levels and type of Application

PSA= Soil Application, **PFA** = Foliar Application, **PSFA** = Soil-Foliar Application.

PSA levels; Control, L1 = 24 Kg K_2O/Fad., L2 = 48 Kg K_2O/Fad., L3 = 72 Kg K_2O/Fad.

PFA levels; Control, L1 = 0.48 Kg K_2O/Fad., L2 = 0.96 Kg K_2O/Fad., L3 = 1.44 Kg K_2O/

PSFA levels: Control, L1 = 24 + 0.48 Kg K_2O/Fad., L2 = 48 + 0.96 Kg K_2O/Fad., L3 = 72 + 1.44 Kg K_2O/Fad.

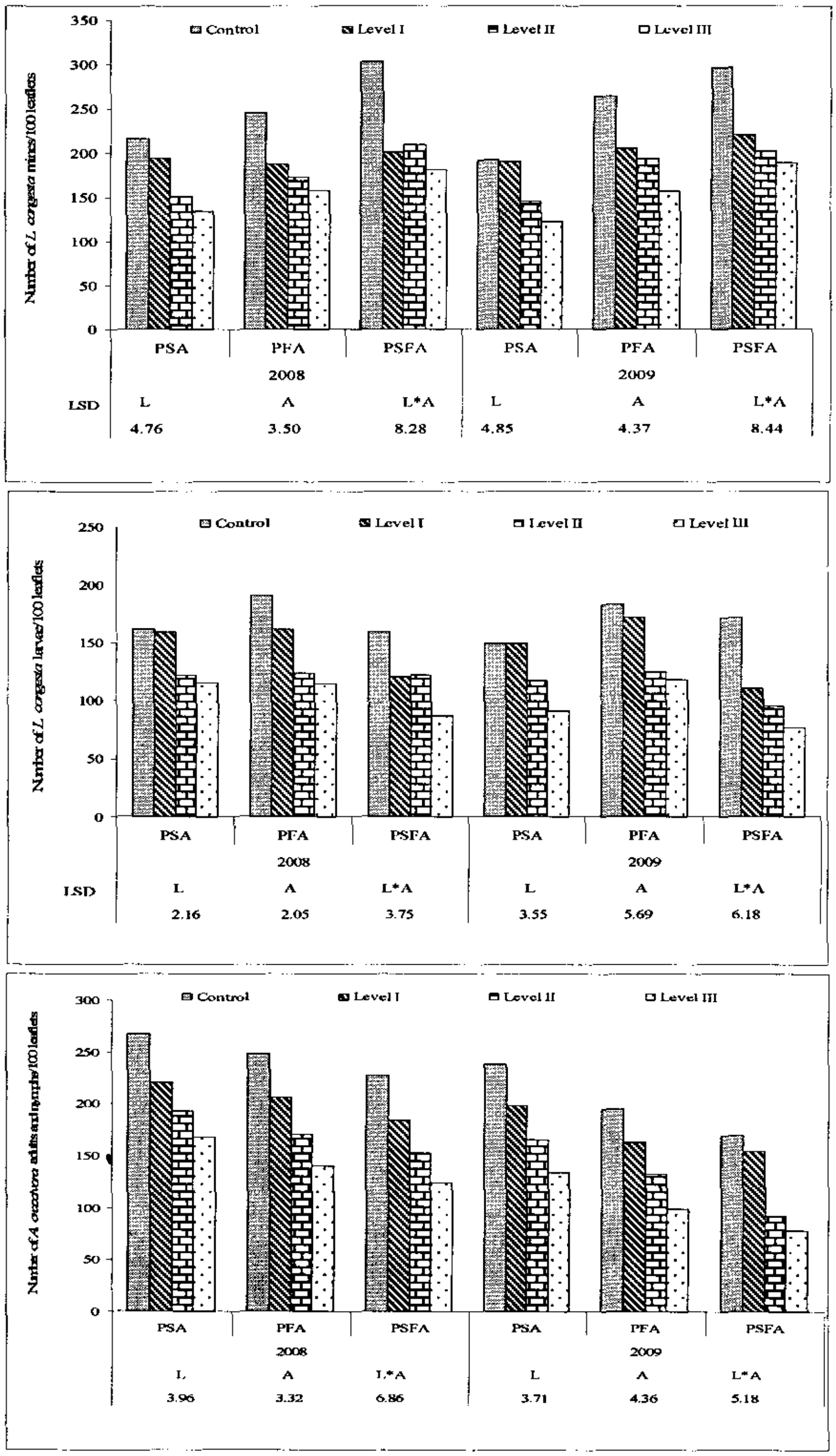

Fig. (2): Effect of different potassium sulphat fertilizer regimes and their levels on the number of *L. congesta* mines and larvae and number of *A. craccivora* adults and nymphs/100 leaflets in *V. faba* (Giza 402) during growing seasons of 2007/08 and 2008/09.

L= Levels A= Type (regime) of Application L*A = Interaction between levels and type of Application

PSA= Soil Application, **PFA** = Foliar Application, **PSFA** = Soil-Foliar Application.

PSA levels; Control, L1 = 24 Kg K_2O/Fad., L2 = 48 Kg K_2O/Fad., L3 = 72 Kg K_2O/Fad.

PFA levels; Control, L1 = 0.48 Kg K_2O/Fad., L2 = 0.96 Kg K_2O/Fad., L3 = 1.44 Kg K_2O/

PSFA levels: Control, L1 = 24 + 0.48 Kg K_2O/Fad., L2 = 48 + 0.96 Kg K_2O/Fad., L3 = 72 + 1.44 Kg K_2O/Fad.

Genetic parameters of *V. faba* under K_2O application:

a. Regression coefficient:

The coefficient of determination (R^2) between seed yield (g/plant) and other yield components was calculated for combined of both studied seasons and presented in Fig. 4. The figure showed greatest direct effect on seed yield/plant, with leaf chlorophyll content (0.968), followed by shedding rate (0.796%) and number of branches/plant (0.736). The lowest effect was noticed with the number of pods per plant (0.527). Similarly, the coefficient of determination (R^2) revealed an important degree of the direct effect of insect infestations on seed yield/plant 0.575, 0.713 and 0.388 for number mines/100 leaflets, number larvae/100 leaflets of *L. congesta* and number of *A. craccivora* adults and nymphs/100 leaflets, respectively.

b. Phenotypic correlation:

Phenotypic correlations among all studied traits are presented in Table (3). Significant positive correlation values were detected between seed yield/plant (g/plant) and each of days of 50% flowering, numbers of branches/plant, number of pods/plant and leaf chlorophyll content (SPAD-value), while it was negative and non significant with shedding rate (%).

On the other hand, negative and significant correlations has been recorded between seed yield/plant and insect infestation of *L. congesta* as the number of mines/100 leaflets (-0.774**, -0.687**, and -0.727**), number of larvae/100 leaflets (-0.797**, -0.670** and - 0.724**) and *A. craccivora* infestation as the number of individuals/100 leaflets (-0.790**, -0.676** and - 0.729**) in 2007/08, 2008/09 seasons and their combined, respectively. The same trend of correlation was observed between leaf chlorophyll content (SPAD-value) and insect infestations of *L. congesta* and *A. craccivora* (Table 3). Whereas, positive and significant values of correlation were detected between insect infestations and shedding rate in both seasons of 2007/08, 2008/09 and combined.

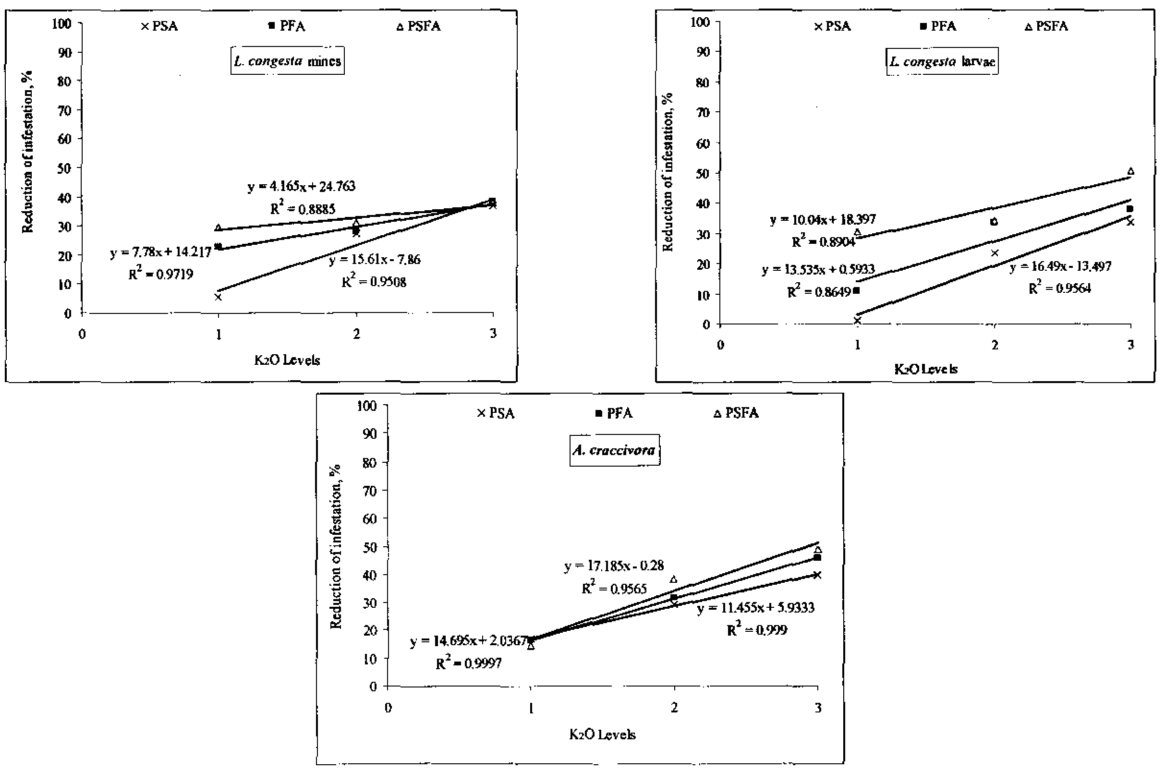

Fig. (3): Relationship between reduction percentage of insect infestation and K_2O levels at different application regimes in *V. faba* plants. The line of linear best fit, the regression equation, and the coefficient of determination.

Table (2): Equation models of relationships between reduction of insect infestation and levels of potassium fertilization at different application regimes in *V. faba* plants.

Insect species	Regression equation, *y* (Reduction, %) =		
	PSA	**PFA**	**PSFA**
L. congesta larvae	16.49*x** - 13.497	13.535*x* + 0.5933	10.04*x* + 18.397
L. congesta mines	15.61*x* – 7.86	7.87*x* + 14.217	4.165*x* + 24.763
A. craccivora individuals	11.455*x* + 5.933	14.695*x* + 2.037	17.185*x* - 0.28

**x* level of K_2O, according to application regime.

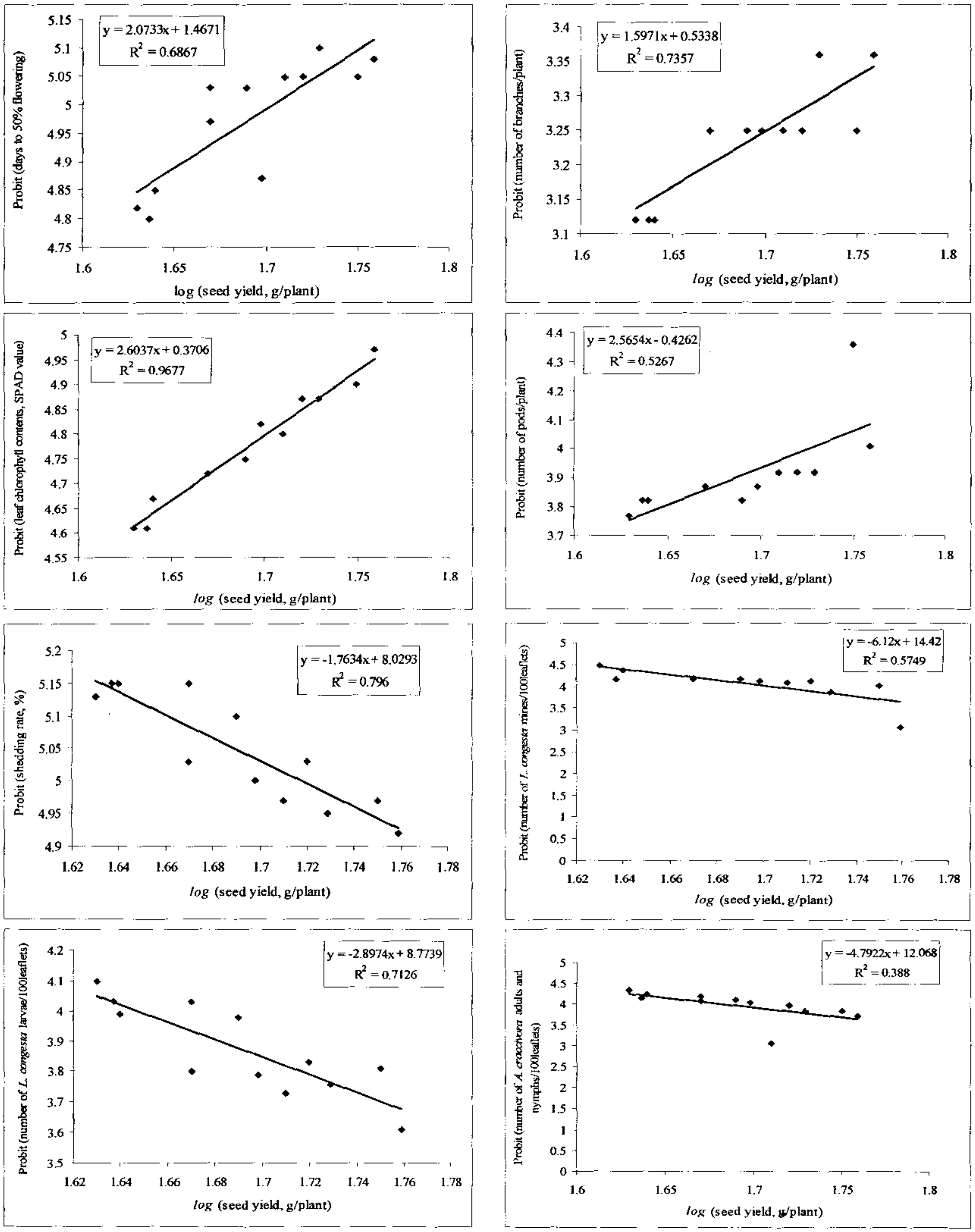

Fig. (4): Regression coefficient between seed yield (g/plant) and days to 50% flowering, number of branches/plant, number of pods/plants, leaf chlorophyll content, shedding rate, number of *L. congesta* mines, number of *L. congesta* larvae and number of *A. craccivora* adults and nymphs/100 leaflets in combined seasons (2007/08 & 2008/09).

Table (3): Correlation coefficients between recorded parameters through seasons 2007/08, 2008/09 and their combined of faba bean (cultivar, Giza 402).

Traits	Years	Days to 50% flowering	Number of branches/ plant	Leaf chlorophyll content (SPAD-value)	Number of pods/ plant	Shedding rate (%)	Seed yield (g/plant)	Number of mines/ 100 leaflets	Number of larvae/ 100 leaflets	Number of aphid individuals/ 100 leaflets
Days to 50% flowering	2007/08	------	0.754**	0.769**	0.818**	- 0.118	0.846**	- 0.502**	- 0.494**	- 0.524**
	2008/09	------	0.794**	0.820**	0.836**	-0.121	0.869**	-0.637**	-0.471**	-0.492**
	Comb.	------	0.745**	0.794**	0.825**	-0.110	0.858**	-0.575**	-0.481**	-0.423**
Number of branches/plant	2007/08		------	0.824**	0.856**	- 0.036	0.903**	-0.607**	-0.678**	-0.771**
	2008/09		------	0.883**	0.895**	0.012	0.872**	-0.609**	-0.725**	-0.721**
	Comb.		------	0.814**	0.827**	-0.0.46	0.843**	0.552**	-0.662	-0.602
Leaf chlorophyll content (SPAD - value)	2007/08			------	0.882**	- 0.206	0.932**	- 0.802**	- 0.811**	- 0.827**
	2008/09			------	0.859**	0.258	0.942**	- 0.769**	- 0.772**	- 0.763**
	Comb.			------	0.867**	- 0.237*	0.932**	- 0.784**	- 0.776**	- 0.696**
Number of pods /plant	2007/08				------	- 0.004	0.864**	-0.666**	-0.642**	-0.648**
	2008/09				------	- 0.212	0.863**	-0.599**	-0.887**	0.776
	Comb.				------	-0.0.97	0.862**	-0.631**	-0.592**	-0.571**
Shedding rate (%)	2007/08					------	-0.221	0.394*	0.462**	0.560**
	2008/09					------	- 0.181	0.262*	0.517**	0.510**
	Comb.					------	0.188	0.327*	0.449**	0.439**
Seed yield (g/plant)	2007/08						------	- 0.774**	- 0.797**	- 0.790**
	2008/09						------	- 0.687**	- 0.670**	- 0.676**
	Comb.						------	- 0.727**	- 0.724**	- 0.729**
Number of mines/100 leaflets	2007/08							------	0.851**	0.801**
	2008/09							------	0.814**	0.910**
	Comb.							------	0.825**	0.721**
Number of larvae/100 leaflets	2007/08								------	0.763**
	2008/09								------	0. 639**
	Comb.								------	0.710 **
Number of aphid individuals/100 leaflets	2007/08									------
	2008/09									------
	Comb.									------

*, ** Denotes significant at 5% and 1% level of probability, respectively.

DISCUSSION

The yield of faba bean may become unstable as the result of insect invasion (Hawtin and Hebblethwaite, 1983). Therefore, there is a great desire for improving the yield productivity, inherit field potential and yield stability of faba bean. Recently, several programs for pest control have been developed to enhance resistant varieties in order to reduce crop losses caused by insects. One of these programs is the use of suitable agricultural practices, including fertilizers. In this respect, potassium application could be used to minimize the harmful effects of insect injury.

Effect of K_2O on seed yield and its components:

In general, potassium fertilization clearly caused significant decrease in the percentage of shedding rate compared to control, as well as increasing in number of branches, leaf chlorophyll content, number of pods/plant and seed yield (g/plant). It means that the use of potassium sulfate may lead to improve the negative effects of stress in faba beans (Abdel-Wahab and Abd-Alla, 1995). Its application has considerable effects on wheat grain, increased the grain protein content and improved wheat grain quality (Bahmanyar and Ranjbar, 2008).

Our findings regarding the studied characters are in consistent with earlier studies. Oosterhuis (2001) mentioned that K^+ implicated in over 60 enzymatic reactions involving many processes in the plant such as photosynthesis, respiration, carbohydrate metabolism, translocation and protein synthesis. Bednarz and Oosterhuis (1999) found that chlorophyll content in leaves of cotton plants decreased under K^+ deficiency, leading to highly reduction of photosynthesis reached to 95%. Whereas, plants that had an optimum level of potassium will be more efficient in photosynthesis. Also, the rate of photosynthesis increased with the increase of the level of potassium (K^+) in plant leaves (Mazher *et al.*, 2007).

Application types of K_2O:

The obtained data indicated that the most effective treatment of potassium fertilization was observed in the soil-foliar application (PFSA). Potassium is primarily soil-applied, but it could be sprayed as a water solution on the foliage for more rapid uptake (Eibner, 1988), and it used as foliar fertilizers. Moreover, Abou El-Nour (2002) concluded that the foliar fertilization as supplementary potassium application not only reduce the amounts of soil potassium application, but also have a positive effect on faba bean yield and its quality.

Foliar application of nutrients is in general helpful to satisfy plant requirement and has a high efficiency (Inglese *et al.*, 2002). It can be more efficient than soil application, since the effect of foliar application of potassium was superior to soil application, which implies that this technology is preferable. Potassium is particularly well adapted to this form of fertilization due to rapid translocation from the leaves (Mengel, 2002). Whereas, combination of soil-applied and foliar applied is recommended for nutrient management (Amiri, 2008). At the same time, Ibrahim and Eleiwa (2008) stated that foliar feeding of a nutrient may actually promote root absorption of the same nutrient through improving root growth and increasing nutrients uptake.

Effect of K_2O on plant resistance to insect pests:

It is well known that, potassium plays an important physiological roles including building up of resistance to insect pests by influencing tissue of cell structures and biochemical processes. K^+ nutrition has a profound effect on the profile and distribution of primary metabolites in plant tissues, which in turn could affect the attractiveness of the plant for insects and pathogens as well as their subsequent growth and development on and in the plant (Amtmann *et al.*, 2008). Physical resistance to pests is improved because adequate potassium supply ensures complete closure of plant stomata, increases the lignifications of vascular tissue and increase waxes on the surface of leaves and needles, which would help with the hardening process (Landis, 2005). Griffith & Wagner (1966) speculated that cereal plants exhibited thicker cuticles and more turgid cells when plant tissue was obtained high concentration of potassium. A thicker cuticle in plants can be considered as a first line of defense to disease and insect attack and increases the resistance to insect feeding, especially against sucking insects (Khattab, 2007). Results of this research confirmed significant effect of potassium fertilization on the insect infestations. These findings are in agreement with those reported by (Kindler and Staples, 1970) who found that increasing amount of potassium and phosphorus fertilizer, increased resistance against spotted alfalfa aphid in alfalfa, green bug in sorghum (Schwessing and Wilde, 1979), and fall armyworm in pearl millet (Leuck, 1972).

Therefore, using potassium (K^+) fertilization as a soil-foliar application or adding more of potassium element is so necessary for encouraging the defensive system of plant to be more resistant or tolerant to insect injury caused by *Liriomyza congesta* and *Aphis craccivora*. These results confirm that potassium element, in form of PSFA, was more effective in reducing the insect infestations. Similarly, Elden and Kenworkthy (1995) found that the optimum or higher levels of soil potassium have been implicated with a decline in the incidence of disease and insect pests in several plant species.

Regression coefficients and phenotypic correlation:

Coefficients of determination (R^2) might be permit to evaluate and select the predictive and reliable parameters to determine screening criteria for the best of k^+ application methods to improve agronomic traits and resistance to insect infestations of faba bean. If the coefficient of determination is significant, the studied characters may reflect the degree of variation, and may indicate useful criteria for the seed yield improvement studies. In this respect, Ulukan *et al.* (2003) found the direct and indirect effects of plant height, pod number/plant and seed number/pod upon biological yield, whereas, the total determination coefficient was found to be 0.636 in the model used.

However, the liner regression equation considered the best fit relationship in this respect between seed yield (g/plant) and the related agronomic characters and insect infestations under potassium (K^+) fertilizer application levels. This means that the importance of selection the optimum application methods for resistance to insect infestation of *L. congesta* and *A. craccivora* for improving seed yield of faba bean. The knowledge of the type of relationship between seed yield and all studied characters is necessary to plant breeders, to avoid selecting against desirable and resistance important characters, including the ability of faba bean plant to insect resistance.

The results indicated that the degree of association, which was highly significant between the agronomic character pairs, could be accompanied by high yielding ability under such conditions. Therefore, it could be conclude that selection of faba bean plants under potassium (k^+) fertilizer application should be based on the above characters to improve seed yield of faba bean (Giza 402). These results are in agreement with those reported by Alghamdi and Ali (2004), Alan and Geren (2007).

On the other hand, increasing of insect infestations led to considerable reduction in leaf chlorophyll content and faba bean seed yield. In this respect, leaf miner and cowpea aphid consider the most destructive pests caused important losses of faba bean yield (El-Hosary *et al.,* 1998). The obtained results confirmed that the selection to the high level of resistance of insect infestation depends on content of the leaf chlorophyll, while no effects for the percentage of shedding rate on resistance degree to insect infestation. These findings are in agreements with the results reported before by El-Hosary *et al.* (1998) and Awaad *et al.* (2005).

CONCLUSION

In conclusion, data confirmed the possibility of using potassium fertilization for improving yield components and insect resistance of faba bean. The obtained results proved that the most effective potassium fertilization was observed in the soil-foliar application treatment. Potassium fertilization as a soil-fliar application or increasing its levels is so essential to encourage the plant to be high yield potential and more resistance or tolerance to insect injury causing by *L. congesta* and *A. craccivora*. However, further studies are required to clarify the mechanisms of potassium element as a major implication for plant mineral nutrition for improving the resistance to insect injury, as well as seed yield and its related characters of faba bean plants. Also, it could be concluded that introducing of K_2O fertilization as an agricultural mean through the obtained equation models (Table 2) may be considered one of the useful tools in IPM during controlling of such insect pests of *Vicia faba*.

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تأثير التسميد البوتاسى على المكونات المحصولية والمقاومة للإصابة بنافقات الأوراق والمن فى محصول الفول البلدى

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يهدف هذا البحث لدراسة تأثير طرق إضافة ومستويات التسميد البوتاسي على المكونات المحصولية ودرجة الإصابة بكل من نافقة أوراق الفول *Liriomyza congesta* ومن اللوبيا *Aphis craccivora* لمحصول الفول البلدي. تم إجراء التجارب فى المزرعة التجريبية بكلية الزراعة – جامعة قناة السويس خلال موسمين متعاقبين (٢٠٠٧/٢٠٠٨، ٢٠٠٨/٢٠٠٩) على أحد أصناف الفول البلدى (جيزة ٤٠٢ – حيث أنه صنف حساس للإصابة الحشرية). أوضحت النتائج أن هناك تأثير معنوى للتسميد البوتاسي على كل من مكونات المحصول ودرجة المقاومة للإصابة الحشرية. أدت كل من المعاملة الأرضية والورقية للبوتاسيوم إلى زيادة معنوية فى محصول البذرة ومكوناته ، بينما أدت إلى تناقص معنوي فى تعداد كل من نافقة أوراق الفول ومن اللوبيا. كانت معاملة التسميد الأرضى والورقى معاً هى الأكثر كفاءة فى تحسين الصفات المحصولية مثل تاريخ ٥٠% من التزهير ، محتوى الكلوروفيل بالأوراق ، عدد القرون لكل نبات ، محصول البذرة (جرام/نبات)، التى إزدادت تدريجياً بزيادة مستوى التسميد البوتاسي. كما لوحظ زيادة درجة المقاومة لكل من نافقة أوراق الفول ومن اللوبيا مع زيادة مستويات التسميد البوتاسى خلال موسمى الدراسة. أكدت النتائج المتحصل عليها أن الإنتخاب للمستوى العالى من المقاومة للإصابة الحشرية يعتمد على محتوى الكلوروفيل بالأوراق، فى حين لم يكن لنسبة التساقط تأثير على الإنتخاب لصفة المقاومة. كانت هناك علاقة إنحدارية بين معدل الخفض فى الإصابة الحشرية ومستويات التسميد البوتاسي فى كل المعاملات وأنظمة التطبيق المختلفة. أيضاً أظهرت قيم معامل الإرتباط أهمية إدراج صفة المقاومة للإصابة الحشرية لكل من نافقة أوراق الفول ومن اللوبيا ضمن برامج التربية لتحسين محصول الفول البلدي.